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## **Chrome Plating Projects at Watervliet Arsenal**

**Fiscal Year 2000**

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## Foreword

This research was funded under 622720960, "Congressional — Watervliet Arsenal Pollution Projects." The project was co-developed under the Value Engineering Program of the U.S. Army Corps of Engineers. The two projects described in this report were conducted at Watervliet Arsenal (WVA) during Fiscal Year (FY) 2000. The WVA technical monitor was Phil Darcy, Benet Laboratories.

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# Contents

<b>Foreword</b> .....	<b>2</b>
<b>1 Introduction</b> .....	<b>5</b>
Background .....	5
Objective.....	6
Approach .....	6
Mode of Technology Transfer .....	7
<b>2 Project One — Minor Parts Chrome Plating Facility Upgrade</b> .....	<b>8</b>
Chrome Plating Line 3 Hoist Controls Upgrade and Minor Plating Temperature Monitoring Guide.....	8
Project Overview .....	8
Detailed Description of Project One .....	9
<i>Site Investigation</i> .....	9
<i>System Hardware Design</i> .....	9
<i>Software Design: PLC Ladder Logic</i> .....	10
<i>Software Design: HMI Programming</i> .....	11
<i>Training and Operations and Maintenance (O&amp;M) Manual</i> .....	11
<b>3 Project Two — 120-mm Chrome Plating Facility Upgrade</b> .....	<b>13</b>
Chrome Mag-Drive Pump Upgrade.....	13
Project Overview .....	13
Detailed Description of Project Two .....	13
<i>Site Investigation</i> .....	13
<i>System Hardware Design</i> .....	14
<i>System Electrical Design</i> .....	14
<i>Training and O&amp;M Manual</i> .....	14
<b>4 Summary</b> .....	<b>16</b>
<b>Related Publications</b> .....	<b>17</b>
<b>CERL Distribution</b> .....	<b>18</b>
<b>Report Documentation Page</b> .....	<b>19</b>

# 1 Introduction

## Background

The projects described in this report are among several projects at Watervliet Arsenal (WVA), NY, which were conducted as a collaborative effort by MSE-Technology Applications, Inc. (MSE), Benet Laboratories and the U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (CERL).

The first project "Chrome Plating Line 3 Hoist Controls Upgrade and Minor Plating Temperature Monitoring Upgrade" was performed because existing instrumentation used to control the Line 3 crane and hoist, which are used to move minor components between process tanks in the chrome plating facility, is outdated and for the most part inoperative. Lack of properly working automatic crane controls means that the operator must walk the crane down the process line in manual mode. Even in manual mode, the crane is only intermittently operative. By requiring the operator to use the system in manual mode, a greater degree of operator error is introduced into processing and environmental safety and health (ES&H), which includes the possibility of inhalation of harmful gases or skin contact with chemicals.

Existing temperature controls of heated and cooled tanks consist of on/off valves, which are mechanically controlled by vacuum-sealed capillary tubing and temperature sensors located in the liquid baths. Because the existing controls were entirely mechanical, there were no devices to record and document the required temperature settings. Accurate documentation and proof of maintained temperatures are necessary in order for WVA to retain its International Organization for Standardization (ISO) 9000 certification. Also, because of the difficulty in obtaining the correct setting for a desired temperature set-point, and because of the mechanical nature of obtaining the set-point, operators maintained heat in the tanks at all times, which resulted in a waste of steam energy. Digital reading devices were needed to overcome these problems.

Another problem at WVA was the fact that the existing chromic acid and electropolish pumps in the 120-mm plating facility are sealed pumps. The highly corrosive media, the build-up of pressure, and the relatively high temperature in the

process streams caused the seals in the pumps to break down frequently. Seal failure results in plating facility downtime and maintenance labor costing approximately \$200,000 per year. To reduce seal failure, cooling water is routed through the casing around the seals, which means the treatment plant receives approximately 1 million gallons per year of wastewater (the cumulative total for two chromic acid pumps and three electropolish pumps).

Additionally, the existing chromic acid pumps are rated at 30 horsepower. A recent upgrade replaced one of the pumps with a sealless magnetic drive pump rated at 15 horsepower. This pump has proven itself more than capable of providing the necessary head to cycle the chromic acid through the system and, after 2 years of service, has not required any maintenance downtime. Upgrading the remaining pumps would provide more efficient fluid movement and a significant reduction in energy costs. These problems were addressed in the second project "Chrome Mag-Drive Pump Upgrade."

## Objective

The objective of the first of these two projects was to reduce operator hazards by installing new hoist controls to replace the existing inoperative controls on Line 3, and to reduce energy usage by installing instrumentation to monitor the temperature of various critical process tanks on Lines 1, 3, and 4.

The objective of the second project was to reduce the amount of downtime in the plating facility, reduce energy consumption, reduce wastewater, and reduce maintenance hazards from the handling, cooling, and replacement of existing pump seals.

## Approach

For the first project, the approach was to upgrade the minor plating Line 3 crane to reduce operator hazards and eliminate parts waste by having a working crane (with tank soak times now running efficiently), to design an upgrade to the temperature instrumentation to ensure that plating temperatures are maintained for critical parts manufacturing, and to provide a design to upgrade the operator interface computer located in the Internally Contained Environment (ICE)-Station in Minor Plating (ICE is manufactured by Integration Technology Systems, Inc., Mt. Pleasant, PA).

The approach to the second project was to upgrade the 120-mm chrome plating facility through the removal of outdated and oversized pumps and to subsequently install sealless pumps, which are maintenance free and require no cooling water, and power monitors in the motor feed buckets to protect the pumps and motors in the event of low flow conditions or pipe blockage.

### **Mode of Technology Transfer**

Transfer of this technology to the private sector will be accomplished through New York State Department of Environmental Conservation (NYSDEC), Environmental Protection Agency (EPA), and Department of Defense (DoD) Pollution Prevention Committee. The Benet Laboratories plating shop initiative will transfer this technology to other DoD plating and metal finishing operations. Benet Laboratories website is <http://www.benet.wva.army.mil/>. Additional technology transfer will be through the Army Materiel Command's Pollution Prevention Centers of Technology Exchange (P2CTX) Program.

This report will be available on both the CERL and the WVA web sites. The CERL web site address is: <http://www.cecer.army.mil>. The WVA web site address is: <http://www.wva.army.mil>.

## 2 Project One — Minor Parts Chrome Plating Facility Upgrade

### Chrome Plating Line 3 Hoist Controls Upgrade and Minor Plating Temperature Monitoring Guide

This project was the second phase of upgrading the hoist controls and vessel temperature controls associated with the minor component cleaning, anodizing, and chrome plating facility. Process Lines 1, 3, and 4 are in Building 35 East at WVA. An overview of the project follows.

#### Project Overview

The first task of the project was to upgrade the minor parts chrome plating facility, which was accomplished by:

- Removing existing NAPCO International hardware and software in Line 3 hoist control panels (two hoists, therefore two sets of controls);
- Installing new hardware ([Allen-Bradley [Milwaukee, WI] SLC-5/04 programmable logic controller [PLC]) and software (RSLogix [Allen-Bradley] ladder programming) in the Line 3 hoist control panel, and providing a data link to the interface computer in the ICE-Station;
- Replacing Line 3 photo light system with distance meters (two each);
- Installing uninterruptible power supply (UPS) in Line 3 control panel;
- Replacing Line 3 bath-occupied sensors (two each).

The second task was to provide a design to upgrade the temperature instrumentation for the following 19 tanks:

- Temperature control instrumentation on critical process tanks 28, 30, 32, and 33 on Line 1
- Temperature control instrumentation on critical process tanks 3, 4, 6, 7, 8, 19, 20, 21, 22, 25, and 26 on Line 3
- Temperature control instrumentation on critical process tanks 4, 5, 8, and 9 on Line 4.

The last part of the project was to provide a design to install an operator interface digital temperature recorder located in the NAPCO International panel in Minor Plating. MSE-TA accomplished this task by completing the following steps:

- Removing the NAPCO read/write programmer, the Texas Instruments sequencer and expander, relay boards, and input/output (I/O) modules
- Installing the 20-channel recorder in the panel
- Installing alarm circuits using relay outputs on the recorder (these alarms announce high or low temperatures in the chrome tanks or cleaning tanks)
- Designing temperature data accessibility to the Environmental Management Information System (EMIS)
- Designing minor plating scrubber air monitoring information screens for the Human Machine Interface (HMI) computer in the 120-mm control panel (main floor of Building 35)
- Installing a PLC processor (smart controller) in the minor plating chassis
- Providing design for accessing amperage levels on a third portable rectifier (recently installed) on Line 1, and incorporating these data into the scrubber air monitoring HMI screens
- Providing design for accessing amperage levels on five additional stationary rectifiers on Line 1, and incorporating these into the scrubber air monitoring HMI screens.

## **Detailed Description of Project One**

### ***Site Investigation***

The initial task was to investigate the site and meet with the principles at WVA to confirm the scope of work, to build the existing hoist equipment and temperature indicators/controllers, and to make preliminary determinations for location of new equipment.

### ***System Hardware Design***

The second task of this project was to upgrade equipment, as follows:

1. Replaced the existing Line 3 NAPCO read/write programmer, timeways, and relay control wiring with an Allen-Bradley SLC-5/04 PLC, input and output cards, RSLogix ladder programming, and an Allen-Bradley Panelview 600 display and operator interface. Programs can now be downloaded from a laptop computer, rather than by repetitive pushbutton entries. To maintain uniformity, this



equipment duplicates the equipment installed on the Line 1 hoist upgrade panel. Panelview screens that were developed include:

- Hoist and work bar location scree
- Semi-automatic control
- Systems status
- Emergency shutdown.

The existing NAPCO panel and wiring to the ribbon cables on the crane were re-used for the new hoist controls.

2. The photo light system, which was used for crane location sensing, was disconnected and replaced with Spectra Precision distance meters and reflector plates. The laser technology used in these distance meters is immune to the buildup of dirt and grime. This buildup was the cause of persistent problems with the previous crane positioning system. Conduit and communication cable were installed between the control panel and the distance meters. Two of these are required for Line 3.
3. The Line 3 bath-occupied sensors were replaced (two required, one for each crane/hoist) with new Allen-Bradley optical sensors. For uniformity, these new sensors are the same model as those on Line 1. The bath-occupied reflectors were re-used.
4. The existing temperature controls on two cooled tanks (19 and 20) in Line 3 were re-designed with updated controllers, sensors, and electric solenoid valves. In addition, the temperature signals were added to the digital multi-point recorder to provide temperature maintenance documentation.
5. The steam valves were designed to be installed fail-safe to the closed position in the event of power loss.
6. To avoid depletion of fluid levels (and subsequent burnout of tank liners) in Line 1 chrome tanks 28, 30, 32, and 33, longer temperature probes extending to a level 5 in. (12.7 cm) from the bottom of the tank were installed. In addition, signals were input to the digital recorder in the main panel for maintaining temperature documentation.
7. The mechanical sensor and valve in Line 3 tank 4 were replaced with an electric valve and a new controller with on/off control. This controller was installed in the main control panel near the crane HMI screen.

### ***Software Design: PLC Ladder Logic***

The ladder logic software installed in the SLC-5/04 performs all control functions associated with the crane and hoist movement. The operator enters a command (move to new tank, lift hoist, lower hoist, etc.) on the Panelview 600. This

command is relayed to the PLC, which then checks field position of the crane (input from the distance meters), status of hoist limit switches, and bath-occupied status. After field status is determined, the PLC directs crane or hoist movement if all permissives are cleared. No illegal moves are permitted. For example, a work bar would not be allowed to be lowered into a tank already occupied, even if commanded to do so by the operator.

### ***Software Design: HMI Programming***

Wonderware (Irvine, CA) InTouch v7.0 was used as the HMI software installed on the scrubber air-monitoring computer on the upper level of Building 35 (120-mm plating facility). Operator interface screens developed for the computer include (in addition to the screens developed for 120-mm major plating):

- Minor plating scrubber view screens with displays of pertinent data
- A tank rectifier status and amperage value screen that shows the status of any of eight stationary rectifiers or three portable rectifiers
- Scrubber compliance screens showing scrubber and rectifier data at any point in time, as well as the air emission compliance status of the scrubbers each day.

This task was accomplished in cooperation with the ES&H personnel at WVA. The HMI software was interconnected, configured, and tested at MSE in Butte, MT.

### ***Training and Operations and Maintenance (O&M) Manual***

An O&M manual was written for the temperature monitoring upgrade. This manual includes sections on vendor information, loop descriptions, and calibration of temperature controls and monitoring equipment. Drawings of each loop are also included in the manual. One copy of the manual will remain in the ICE-Station panel for user reference.

An additional O&M manual was written for the new hoist controls on Line 3. This manual includes vendor cut sheets and O&M and troubleshooting sections for the new hoist controls.

Training sessions for the new crane controls were held in the minor plating section for WVA personnel from Engineering, ES&H, and O&M. The sessions included an overview of the O&M manual, as well as descriptions of the operator interface panels, and hardware equipment troubleshooting. A separate training session was provided for O&M personnel on the temperature control and monitoring equipment. Copies of all software files were delivered to WVA computer

support personnel to use in the event of a catastrophic failure or loss of memory within the PLC or computer.

### 3 Project Two — 120-mm Chrome Plating Facility Upgrade

#### Chrome Mag-Drive Pump Upgrade

This project was to upgrade the two chromic acid pumps, three electropolish pumps, and one emergency waste pump in the 120-mm chrome plating facility. The pumps are in Building 35 at WVA. An overview of the project follows.

#### Project Overview

This upgrade of the 120-mm chrome plating facility was accomplished by:

- Removing the two remaining water-cooled seal-type chromic acid pumps
- Installing two new magnetic drive sealless chromic acid pumps
- Removing the three water-cooled seal-type electropolish pumps
- Installing three new magnetic drive sealless electropolish pumps
- Removing one water-cooled seal-type emergency transfer pump
- Installing one new sealless magnetic drive emergency transfer pump
- Installing power monitors in all six pump motor feed buckets
- Removing motor speed analog indicators from the main control panels (CP-201 and CP-301)
- Connecting motor speed indicator signals to the 30-channel digital recorders (installed under the chrome plating upgrade project)
- Installing alarms on the main level of the 120-mm plating facility to indicate power monitor or emergency shutdown of the six new pump motors.

#### Detailed Description of Project Two

##### *Site Investigation*

The initial task was to investigate the site and meet with the principles at WVA to confirm the scope of work, to build the existing chromic acid pumping system, and to make physical measurements for determination of pipe length adjustments to accommodate installation of new equipment.

### ***System Hardware Design***

The second task of this project was to upgrade hardware. The following tasks were accomplished.

1. The wiring and pipe connections to the two chromic acid pumps, three electropolish pumps, and one emergency transfer pump at the bottom level of the 120-mm pit were disconnected. Using a jib and crane arrangement, the old pumps were lifted out of the pit for disposal by WVA personnel.
2. New magnetic-drive pumps were lowered into the 120-mm pit using the jib and crane arrangement and then bolted to the cement platforms. Piping and wiring were reconnected. New flexible joints connecting the outlet pipes to the pumps were required because of the smaller physical size of the new pumps.

### ***System Electrical Design***

Electrical upgrades to the system are as follows:

1. The feed bucket circuits supplying power to the pump motors were designed to accommodate power monitors in the buckets. The breaker heaters were resized to account for the smaller horsepower motors. The plan for the power monitors was to install them so that they have analog outputs that can be used to supply recording and alarm circuits.
2. Audible alarms were installed in the main chrome plating consoles (CP-201 and CP-301). These alarms alert the plating operator that one of the chromic acid or electropolish pumps has failed due to an abnormal power condition (the power monitor has shut down the pump), or the emergency stop button was pushed by an operator located in the pit.

The installation of power monitors in the pump feed buckets provides a means of shutdown in the case of any abnormal condition, such as low power when dry-running occurs, or high power due to pipe blockage or impeller jamming. Power monitor interruption of the pump motor circuits initiates an audible alarm in CP-201 or CP-301, which are the main operator consoles in the 120-mm plating facility.

### ***Training and O&M Manual***

An O&M manual was written for the magnetic drive pump upgrade. This manual includes sections on vendor information and operation of the pumps and power monitoring equipment. Drawings of each new pump circuit will be

included in the manual. One of the manuals will remain in the main operator panel for user reference.

Because of operator and maintainer familiarity with the existing chromic acid mag-drive pump, training on the new pumps was minimal. Training sessions were provided for maintenance of the power monitoring circuits, the recording and indicating circuits, and for operation and acknowledgement of the alarm circuits.

## 4 Summary

The Line 3 crane upgrade and the design of the tank temperature controls, as described in Project One, produced a number of benefits for WVA. These benefits include: reduction of energy costs; accurate temperature monitoring of critical processes; safer use of crane hoists; increased production capacity; chrome plating scrubber air compliance monitoring; reduction in scrap and rework; and connection to site-wide EMIS.

The upgrading of pumps to the sealless magnetic drive units, as described in Project Two, also provided a number of benefits for WVA. These benefits include: reduction in plating facility downtime; reduction in maintenance equipment costs; reduction in maintenance labor costs; reduction in hazardous spills of chemicals through leaking seals; reduction in operation/maintenance chemical exposures; reduction in wastewater sent to the treatment plant; reduction in energy costs; and increase in plating efficiency.

Pre-cost and post-cost analyses have been performed. Validated estimated cost savings for this project are:

Savings of \$2.35/gal of water purchased (\$2,421 per year for 1.03 million gal) and an estimated \$40,000 in annual maintenance savings. The total annual savings can be computed as follows:

$$\begin{aligned} & \$72,000 \text{ (wastewater savings)} + \$2,421 \text{ (purchase savings)} + \\ & \$40,000 \text{ (maintenance savings)} = \$114,421 \text{ per year} \end{aligned}$$

$$\text{Ten-yr savings} = \$1,144,210.$$

## Related Publications

Northrup, Jearldine I., Joyce C. Baird, Phil Darcy, and Donald J. Schiller, *Environmental Management Information System (EMIS) at Watervliet Arsenal, NY*, Technical Report (TR) 00-28 /ADA383234 (U.S. Army Corps of Engineers, Engineer Research and Development Center [ERDC], Construction Engineering Research Laboratory [CERL], October 2000).

Northrup, Jearldine I., Joyce C. Baird, and Don Schiller, *Remote Monitoring of Fluid Storage Tanks at Watervliet Arsenal, New York*, TR 98/108/ADA352918 (CERL, August 1998).



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<b>14. ABSTRACT</b> <p>This report describes two projects conducted at Watervliet Arsenal (WVA), NY, during Fiscal Year 2000. The first project included an upgrade of the crane and hoist in the minor parts chrome plating facility. Another problem was the facility's existing chromic acid and electro-polish pumps, which were sealed pumps. The corrosive media, pressure, and high temperature in the process streams caused the pump seals to break frequently. The second project included upgrades to two chromic acid pumps, three electropolish pumps, and one emergency waste pump in the 120-mm chrome plating facility.</p> <p>The hoist and crane upgrade and the design of the tank temperature controls produced a number of benefits including: reduction of energy costs; accurate temperature monitoring of critical processes; safer use of crane hoists; increased production capacity; chrome plating scrubber air compliance monitoring; reduction in scrap and rework; and connection to site-wide EMIS. Benefits of pump upgrading to sealless magnetic drive units include reduction in: plating facility downtime; maintenance equipment/labor costs; hazardous chemical spills through leaking seals; operation/maintenance chemical exposures; wastewater sent to the treatment plant; energy costs; and an increase in plating efficiency.</p>					
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